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- The Effects of Curcumin Against Dengue-2 Virus Based on Immunocytochemistry Technique
- Risk Factors Analysis of Typhoid Fever Occurrence of Inpatient in Kebumen Public Hospital in 2013
- Knowledge, Attitude and Practice on Dengue Fever Transmission Among Urban and Periurban Residents of Dhaka City, Bangladesh
- Geographic Information System (GIS) for Dengue Research in Indonesia: A Review
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- Factors Associated with Delayed Diagnosis Among Tuberculosis Patient in Kebumen District
- Effication Test of Srikaya Seeds Extract (*Annona squamosa* L.) to Kill *Aedes aegypti* Larvae in Laboratory
- Immune Response against Hepatitis B Virus after Vaccination among Low Birth Weight and Preterm Newborns: A Retrospective Cohort Study in Magelang District Central Java
- Tumor Necrosis Factor-Alpha (TNF-Alpha) and Intercellular Adhesion Molecule-1 (ICAM-1) Expression of *Plasmodium berghei* Infected Swiss Mice Treated with Red Fruit (*Pandanus Conoideus* Lam) Ethanol Extract
- Validity of p-LDH/HRP2-Based Rapid Diagnostic Test for the Diagnosis of Malaria on Pregnant Women in Maluku
- Comparing the Sensitivity and Specificity of Zinc Sulphate Flotation Method to Formal Ether Sedimentation Method in Identifying Intestinal Protozoa's Cysts
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Volume 03, Number 02

CONTENTS

- 95 - 102 The Effects of Curcumin Against Dengue-2 Virus Based on Immunocytochemistry Technique
Dewi Marbawati, Sitti Rahmah Umniyati
- 103- 109 Risk Factors Analysis of Typhoid Fever Occurrence of Inpatient in Kebumen Public Hospital in 2013
Rina Hidayani, Hari Kusnanto, Rizka Humardewayanti, Trisno Agung W
- 110 - 120 Knowledge, Attitude and Practice on Dengue Fever Transmission Among Urban and Periurban Residents of Dhaka City, Bangladesh
Muhammad Sohel Rana, Mohammad Syaket Ahmed Shakil
- 121 - 127 Geographic Information System (GIS) for Dengue Research in Indonesia: A Review
Adnanto Wiweko
- 128- 135 Risk Factors of Pneumonia Among Under Five Children in Purbalingga District, Central Java Province
Ni Kadek Nira, Dibyo Pramono, Roni Naning
- 136 - 141 Factors Associated with Delayed Diagnosis Among Tuberculosis Patient in Kebumen District
Edwin Sovvan Aritonang, Ning Rintiswati, Riris Andono Ahmad
- 142 - 148 Effication Test of Srikaya Seeds Extract (*Annona squamosa* L.) to Kill *Aedes aegypti* Larvae in Laboratory
Eny Sofiyatun, Joko Malis Sunarno
- 149 - 154 Immune Response against Hepatitis B Virus after Vaccination among Low Birth Weight and Preterm Newborns: A Retrospective Cohort Study in Magelang District Central Java
Muhardison, Hari Kusnanto, Nenny Sri Mulyani
- 155 - 165 Tumor Necrosis Factor-Alpha (TNF-Alpha) and Intercellular Adhesion Molecule-1 (ICAM-1) Expression of *Plasmodium berghei* Infected Swiss Mice Treated with Red Fruit (*Pandanus Conoideus* Lam) Ethanol Extract
Demianus Tafor, Achmad Djunaidi, Widya Wasityastuti, Eti Nurwening Sholikhah
- 166 - 175 Validity of p-LDH/HRP2-Based Rapid Diagnostic Test for the Diagnosis of Malaria on Pregnant Women in Maluku
Vebiyanti, E. Elsa Herdiana Murhandarwati, Bambang Udji Jokorianto
- 176 - 183 Comparing the Sensitivity and Specificity of Zinc Sulphate Flotation Method to Formol Ether Sedimentation Method in Identifying Intestinal Protozoa's Cysts
Dini Alyani, Elsa Herdiana Murhandarwati, Sri Sumarni, Ernaningsih
- 184 - 195 The Effect of Anticoagulant in Blood Meal Source on the *Aedes aegypti* Reproductive Ability in Laboratory
Novyan Lusiyana, Budi Mulyaningsih, Sitti Rahmah Umniyati

Geographic Information System (GIS) for Dengue Research in Indonesia: A Review

Adnanto Wiweko¹

¹Department of Public Health, University of Mataram, West Nusa Tenggara, Indonesia

Corresponding author: adnanto.wiweko@gmail.com

ABSTRACT

Introduction: Geographic information system (GIS) can be very effective tool in combating dengue infection. However, there is only few study that apply GIS in dengue research in Indonesia

Objectives: The purpose of this literature review is to identify how geographic information system (GIS) applications have been used in dengue mapping in Indonesia and to critically examine the issues, strengths, weakness and challenges inherent to those approaches, especially from the spatial analysis and public health point of view.

Methods: The research articles in English or Indonesian were taken by online only using Google Scholar search engine. Only articles that addressed GIS methodology or dengue-related GIS applications were selected for this review. These articles must contain the combination three words including Geographic Information System (GIS), dengue and Indonesia in its titles or abstracts.

Results: Through the review process, conducted in October 2013, it is evident that the applications of GIS in dengue research can be generally categorized into four issues including dengue risk mapping and surveillance (n = 5), combined remote sensing-GIS (n = 4) web application (n = 2), and climatic and other associated factor with dengue (n = 3). This review explores how GIS approaches have been used to analyze the correlation of dengue incidences with environmental risk factor. GIS also used as a tool to improve dengue surveillance and outbreak management. This review also revealed the lack of GIS techniques using in Indonesian dengue research.

Conclusion: GIS-related methodological techniques and tools can be meaning fully applied in dengue research and management.

Keywords: Geographic Information System (GIS), dengue, Indonesia

INTISARI

Pendahuluan: Sistem informasi geografis (Geographic Information System/GIS) dapat menjadi alat yang sangat efektif dalam menanggulangi infeksi dengue. Namun, hanya sedikit yang menggunakan GIS dalam penelitian dengue di Indonesia

Tujuan: Tujuan dari tinjauan pustaka ini adalah untuk mengidentifikasi bagaimana aplikasi sistem informasi geografis (GIS) telah digunakan dalam pemetaan dengue di Indonesia dan untuk memeriksa secara kritis isu-isu, kekuatan, kelemahan dan tantangan yang terjadi akibat pendekatan-pendekatan tersebut, terutama dari pandangan analisis spasial dan kesehatan masyarakat.

Metode: Artikel penelitian dalam bahasa Inggris atau Indonesia diambil secara online hanya menggunakan mesin pencari *Google Scholar*. Hanya artikel yang membahas metodologi GIS atau aplikasi GIS yang terkait dengan dengue dipilih untuk artikel review. Artikel-artikel ini harus memiliki kombinasi tiga kata yaitu Sistem Informasi Geografis (GIS), demam berdarah dan Indonesia dalam judul atau abstrak.

Hasil: Melalui proses review yang dilakukan pada bulan Oktober 2013, aplikasi GIS dalam penelitian dengue secara umum dapat dikategorikan ke dalam empat hal yaitu pemetaan risiko dan pengawasan dengue ($n = 5$), kombinasi penginderaan jauh-GIS ($n = 4$), aplikasi web ($n = 2$), dan iklim dan faktor lain yang terkait dengan dengue ($n = 3$). Artikel review ini mengeksplorasi bagaimana pendekatan GIS digunakan untuk menganalisis hubungan insiden DBD dengan faktor risiko lingkungan. GIS juga digunakan sebagai alat untuk meningkatkan surveilans dengue dan manajemen wabah. Artikel ini juga mengungkapkan kurangnya penggunaan teknik GIS dalam penelitian dengue Indonesia.

Simpulan: Teknik dan alat metodologis yang terkait dengan GIS dapat sepenuhnya diterapkan dalam penelitian dan manajemen dengue.

Kata Kunci: Sistem Informasi Geografis (GIS), demam berdarah, Indonesia, review

INTRODUCTION

Dengue infection (both of dengue fever/DF and dengue hemorrhagic fever/DHF) is a significant and emerging health problem in Indonesia and other tropical countries. Dengue fever and the more lethal dengue hemorrhagic fever are mosquito-borne diseases¹. They are caused by flavivirus that is transmitted by infected *Aedes* mosquitoes¹. Two fifths of the world's populations are at risk. Dengue vectors can breed in any small amount of water such as vases, flower pots, discarded containers, or used tires².

As a vector borne disease, dengue infection depends on environment factor¹. So it becomes importance to study the disease and other related factor to help health officer make decisions to reduce the incidence and severity of its outbreaks.

Geography and studies of human health and well-being have a long history³. A classic example of the value of a geographically orientated in health studies is John Snow's study of mapping the outbreak of cholera in London

in the mid-19th century that revealed a clustering around a water pump³. GIS or Geographic Information System is a geographic tool that can be applied to gain insight into the relationships between health outcomes and social, demographic, economic, and ecological variables⁴.

GIS can be used to complement conventional ecological monitoring and modeling techniques, and provide means to portray complex relationships in the ecology of disease⁵. In addition, the use of GIS to identify environmental features allows determination of risk factors and delimitation of areas at risk, permitting more rational allocation of resources for cost-effective control. Since 1996, GIS have been used in our territorial cross-sectional and longitudinal parasitological surveys in order to experiment new applications to plan sampling protocols and to display quickly, clearly, and analytically the spatial and/or temporal distribution of parasitological data⁵.

In theory, GIS can be an effective tool in combating dengue infection, however, in

practice there are many challenges to its successful use in Indonesia. The focus of this review is to provide some balance discussion about using GIS in dengue research in Indonesia. A review of this type is needed because much of the literature in this area is written by health or geography researcher only, without collaborate each other. The purpose of this paper is to identify how GIS applications have been used in dengue research in Indonesia and to critically examine the issues, strengths, weakness and challenges inherent to those approaches, especially from the spatial analysis and public health point of view. This paper is not to suggest that GIS technology should be used or not be used in dengue research, but to provide some balance by discussing the strength and limitations of GIS in Indonesian context.

Materials and Methods

Searching strategies and databases searched

This review consisted of a search of online published literature in the English and Indonesian language. Databases were searched using keywords contained in the title, abstract, or descriptor terms. The research article was taken by online only using Google Scholar search engine. The search was restricted to studies reported in English or Indonesian-language journals or reports or other publication and indexed with the keyword strategy outlined in *Table 1*. Databases that were searched included journal web, university database and government office. References within identified articles were reviewed for further studies.

Table 1. Set search terms used in this review

<i>Set Search Terms</i>
<ul style="list-style-type: none"> • 001 GIS OR Geographic Information System* AND Dengue • 002 #1 AND Indonesia • 003 GIS OR Geographic Information System* AND DemamBerdarah • 004 SIG OR SistemInformasiGeografis* AND DemamBerdarah • 005 SIG OR SistemInformasiGeografis* AND Dengue • 006 GIS OR Geographic Information System* AND Disease AND Indonesia • 007 GIS OR Geographic Information System* AND health application • 008 #7 AND Indonesia

Inclusion/exclusion criteria

Only articles that addressed GIS methodology or dengue-related GIS applications were selected for this review. Each included study had to have: 1) primary research, not article; 2) research that conducted in Indonesia; 3) GIS as a measurement and/or analysis tool and/or

application; 4) at least one variable related to the dengue or its vector. The search and review process conducted in October 2013

Systematic review process

The numbers of references searched from Google Scholar database. After reviewing and removing duplicates, references were found of

which 31 were identified following the screening of titles and abstracts. Ultimately, 13 published studies were included in this review.

RESULTS AND DISCUSSION

There were 8 articles in Indonesian language and 5 article in English that contain the combination of three words i.e. Geographic Information System (GIS), dengue and Indonesia in its titles or abstracts. These articles were organized into categories based on the main type of application reported including *dengue risk mapping and surveillance* ($n = 5$), *combined remote sensing-GIS* ($n = 4$) *web application* ($n = 2$), and *climatic and other associated factor with dengue* ($n = 3$). One article organized into 2 categories because contains two type application of GIS⁶.

DENGUE RISK AREA MAPPING

There are 5 research using GIS to model dengue risk area. All of them used scoring and overlay. They scored environmental factor and overlay this into dengue incidences map. High risk area represent by high score.

The environment parameter always used in their research were population density, land use, drainage condition, settlement pattern^{6,7,8,9}. Another parameter was dengue incidences/ reporting cases. Additional parameter was used by Sumunar⁶, Widiyani⁷, and Widianoro⁸. Widiyani⁷ explored about the condition and cleaning water vessel activity related to dengue incidences. Community waste collecting pattern as dengue risk factor parameter was also used in this study. The other additional parameter used Sumunar⁶ was rainfall. Different approach was taken by Widianoro⁸, by using larva and protective factor parameter to developed dengue risk area map.

Despite almost all research in this categories focused on dengue risk area mapping, Apiadsa⁹

moved forward by using GIS- dengue risk area map to assisted dengue outbreak management in Magelang. Perdana¹⁰ also have different approach by exploring how GIS can help dengue surveyor officer.

COMBINED GIS-REMOTE SENSING DENGUE MAPPING

There are 4 researches using combined GIS-remote sensing technique to study dengue-environment correlation. The 3 researches used satellite image and one research used airplane image (foto udara). Apiadsa⁹ and Ruliansyah¹¹ shown how Quickbird, a very high resolution satellite image can be used as environmental data in GIS-dengue mapping. Kiang² using ARIMA to model the dengue cases in Jakarta, Indonesia using TRMM (Tropical Rainfall Monitoring Mission) data and dew point temperature. TRMM is low resolution satellite image. In other hand, Sumunar⁶ used airplane image as a data source of her GIS-dengue mapping. Integration of remote sensing imagery and GIS used to analyze physical environmental risk factors associated with dengue such as land use, altitude, rainfall, settlement and mosquito flying area². The research showed that remote sensing image is useful technique to determine physical environment factor related to dengue

WEB APPLICATION OF GIS-DENGUE MAPPING

There are only 2 researches on Web application of GIS in dengue research. Hidayatullah¹² developed a simple web GIS- dengue risk area in Tegalrejo, Yogya. A simple information map model not only for health officer but also for residences in that area was proposed. Kusnanto¹³ developed a Web-based integrated DHF surveillance in Sleman. This model has made to assist dengue surveillance by health officer.

CLIMATIC AND OTHER FACTOR ASSOCIATED WITH DENGUE

There are only 3 researches in this category. Two research used GIS methodology to correlation between dengue and climatic factor^{14,15}. Astutik¹⁴ shown the correlation between DHF incidences and rainfall in East Java Province. She also offered 3 model spatio-temporal correlations between DHF incidences and rainfall. Bangs et al.¹⁵ shown that an ENSO-driven increase in ambient temperature had a marked influence on increased dengue virus transmission by the vector population. He also explored the associations of entomological and climatic effects that precipitated the epidemic before the influx of reported human cases.

Nagao¹⁶ used GIS to determine geography factor of socio economic that affect DHF Patient in Surabaya He also found that age and socio economic factor affect the mosquito abundance are the most important determinant of the mean age of DHF's patient

There are two interrelated components of disease-GIS research. First is disease mapping and the second is disease modeling. Disease mapping is used to understand the geographical distribution and spread of disease in the past or present^{17,18}. Disease modeling extends the disease-mapping application to (a) predict the future spread of disease, (b) identify factors that may foster or inhibit disease transmission, (c) pinpoint high-risk areas for disease prevention or intervention, (d) target control efforts, (e) identify gaps, and (f) increase stimulus for data collection in these areas^{17,18}.

Many factors are known to contribute to dengue transmission, including environmental conditions, socioeconomic status, and meteorological conditions. Among these factors, meteorological and environmental factors are

perhaps the most noticeable. For example, dengue transmission may increase with the arrival or the end of a rainy season, and lack of sanitation settlement². Temperature, humidity and rainfall are the important environmental determinants for dengue transmission². However, there are only few research in Indonesia focused in this area.

There is only one research on dengue mapping process by a geographer¹⁰. Most of the researcher studied GIS-dengue mapping is public health expert or post graduate students so they only studied by plotting incidence to area map. This is the most basic application and involves mapping the incidence/prevalence of dengue over some geographic area². The focus is on examining past trends as well as the present situation and typically does not include any statistical analysis with the possible exception of correlating dengue incidence/prevalence with population in order to calculate populations at risk. The purpose of these studies is to see the patterns of disease². GIS overlay technique were used in almost all research, but only 2 researches used additional technique (buffering and clustering)^{6,11}.

There are only 2 researches studied on mapping of relationships between dengue incidence/prevalence and other related variables^{14,15}. The timeframe is still on past trends and the present situation. The goal of these studies is to see if any relationships exist between dengue incidence/prevalence and a host of other variables including temperature^{14,15}, rainfall^{14,15}, land use/land cover^{6,7,8,11}, breeding sites^{8,15} and control programs⁹. In most cases these studies involve testing to see if any statistical relationships exist.

Astutik¹⁴ has shown a different approach by using complex statistical method modelling, but very difficult to be implemented by health officer in the field. This literature is future-oriented and focuses on predicting areas of dengue risk. Risk models typically use many of the same variables discussed above, but the difference being that statistical relationships are established between dengue incidence/prevalence (the dependent variables) and a range of independent variables in an effort to predict future cases of dengue

Because data collection is one of the major limitations of using GIS, innovative ways of collecting data are critical to the success of GIS. For the most part, this literature deals with remote sensing in the form of aerial photography⁷ and satellite imagery^{2,11}

The lack of GIS- dengue research in Indonesia showed they are many challenges in GIS- dengue research development. The challenges in using GIS for dengue research can be organized in three parts^{2,5}. The first relates to basic data. Without adequate data, GIS is not very useful. The problems include accurate data on the disease and how it is reported, basic environmental data on land uses, topography, rainfall and demographic data of people. The second relates to technology – specifically computer hardware, GIS software, human resources and training. Based on these data, the biggest problem is only few university have GIS related health expert. This is shown by the fact that 2 of 3 GIS-dengue researches were from Yogyakarta. The third area concerns in methodology development, how can GIS be used to improve our understanding of dengue? As noted, there is no standard methodology in spatial statistical analysis².

There are two potential research areas in GIS- dengue research in Indonesia. They are *Disease mapping*, especially in geodatabase, GIS assisted surveillance, limited resources GIS mapping and web disease mapping and *Disease modeling extends*, especially in spread of disease prediction, pinpoint high-risk areas for disease prevention or intervention, target control efforts, identifying gaps and simple model with limited resources.

CONCLUSION

This review explores how GIS approaches have been used to analyze the correlation of dengue incidences with environmental determinants. GIS also used as a tool to improve dengue surveillance and outbreak management. This review revealed the lack of GIS techniques using in Indonesian dengue research.

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..... it has been reported¹
 according to Sardjito²
 Winstein & Swartz³ conducted
 by Avon *et al.*⁴

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Sample References

Scientific Journal

1. *Standard journal article*

You CH, Lee KY, Chey RY, Menguy R. Electro-gastro-graphic study of patients with unexplained nausea, bloating and vomiting. *Gastroenterology* 1980; 79(2):311-14.

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